

IN THE CLAIMS

What is claimed is:

- 1 1. A slurry comprising:
2 an abrasive; and
3 periodic acid, wherein the pH of the slurry is between about 4 to about
- 4 2. The slurry of claim 1 further comprising a corrosion inhibitor.
- 1 3. The slurry of claim 2 wherein the corrosion inhibitor comprises 1-
2 benzotriazole (BTA).
- 1 4. The slurry of claim 1 further comprising a buffer system comprising
2 an organic acid and a salt of the organic acid.
- 1 5. The slurry of claim 4 wherein the organic acid is selected from the
2 group comprising citric acid, acetic acid, carbonic acid, oxalic acid and
3 ascorbic acid.

- 1 6. The slurry of claim 1 wherein the salt of the organic acid is selected
2 form the group comprising potassium citrate, potassium acetate, potassium
3 bicarbonate, potassium oxalate and potassium ascorbate.
- 1 7. The slurry of claim 1 wherein the periodic acid comprises a molar
2 concentration from about 0.005M to about 0.05M.
- 1 8. The slurry of claim 1 wherein the abrasive is selected from the group
2 comprising silica, alumina, zirconia and ceria.
- 1 9. The slurry of claim 1 further comprising a surfactant.
- 1 10. The slurry of claim 9 wherein the surfactant is selected from the group
2 comprising cetyl trimethyl ammonium hydroxide (CTAOH).
- 1 11. A method of forming a microelectronic structure comprising:
2 providing a substrate comprising a barrier layer disposed on an
3 adhesion layer, wherein the adhesion layer is disposed within a
4 recess and on a first surface of a substrate; and
5 removing the barrier layer from the adhesion layer with a slurry
6 comprising periodic acid and a pH from about 4 to about 8.

1 12. The method of claim 11 wherein providing a substrate comprising a
2 barrier layer comprises providing a substrate comprising a material selected
3 from the group comprising ruthenium oxide, ruthenium, rhenium, rhodium,
4 palladium, silver, osmium, iridium, platinum, and gold and combinations
5 thereof.

1 13. The method of claim 11 wherein removing the barrier layer from the
2 adhesion layer with a slurry comprising periodic acid and a pH from about 4
3 to about 8 comprises removing the barrier layer from the adhesion layer with
4 a slurry comprising periodic acid at a molar concentration from about 0.01M
5 to about .06M, and a pH from about 4 to about 8.

1 14. The method of claim 13 wherein removing the barrier layer from the
2 adhesion layer with a slurry comprises removing a ruthenium oxide layer
3 from the adhesion layer with a slurry at a removal rate of about 900
4 angstroms per minute to about 1500 angstroms per minute.

1 15. The method of claim 11 wherein providing a substrate comprising a
2 barrier layer disposed on an adhesion layer, wherein the adhesion layer is
3 disposed within a recess and on a first surface of a substrate comprises
4 providing a substrate comprising a metal layer disposed on a barrier layer
5 that is disposed on an adhesion layer, wherein the adhesion layer is

6 disposed within a recess and on a first surface of a substrate.

1 16. The method of claim 15 wherein removing the metal layer from the
2 barrier layer comprises removing a copper layer from the barrier layer.

1 17. The method of claim 16 further comprising removing the copper layer
2 from the barrier layer with a slurry at a removal rate of about 250 angstroms
3 per minute to about 800 angstroms per minute.

1 18. The method of claim 11 wherein removing the barrier layer from the
2 adhesion layer with a slurry comprising periodic acid and a pH from about 4
3 to about 8 comprises removing the metal layer from the adhesion layer with
4 a slurry comprising periodic acid at a molar concentration from about 0.004M
5 to about .006M, and a pH from about 4 to about 8.

1 19. The method of claim 18 wherein removing the barrier layer from the
2 adhesion layer with a slurry comprises removing a ruthenium layer from the
3 adhesion layer with a slurry at a removal rate of at least about 1000
4 angstroms per minute.

20. The method of claim 11 wherein providing a substrate comprising a
barrier layer disposed on an adhesion layer, comprises providing a substrate

comprising a barrier layer disposed on a material selected from the group consisting of titanium, titanium nitride, tantalum, tantalum nitride and combinations thereof.

1 21. A method of forming a microelectronic structure comprising:
2 providing a substrate comprising a recess wherein a work
3 function layer is disposed within the recess and on a first surface of
4 the recess, and wherein a fill metal layer is disposed on the work
5 function layer; and
6 forming a metal gate electrode by:
7 removing the fill metal layer until the underlying work
8 function layer is exposed by utilizing a slurry comprising
9 periodic acid at a pH from about 4 to about 8; and
10 removing the work function layer from the first surface of
11 the recess with the slurry.

1 22. The method of claim 21 wherein removing the fill metal layer
2 comprises removing the fill metal layer by utilizing chemical mechanical
3 polishing.

1 23. The method of claim 21 wherein removing the work function layer
2 comprises removing the work function layer utilizing chemical mechanical
3 polishing.

1 24. The method of claim 21 wherein providing a substrate comprising a
2 recess wherein a work function layer is disposed within the recess comprises
3 providing a substrate comprising a recess wherein a work function layer
4 selected from the group comprising ruthenium, ruthenium oxide, titanium
5 nitride, titanium, aluminum, titanium carbide, aluminum nitride, and
6 combinations thereof is disposed within the recess.

7 25. The method of claim 21 wherein providing a substrate comprising a
8 recess wherein a work function layer is disposed within the recess and on a
9 first surface of the recess comprises providing a substrate comprising a
10 recess wherein a work function layer includes a sufficient amount of an
11 impurity to shift the work function of the work function layer by at least about
12 0.1 eV.

1 26. The method of claim 25 wherein providing a substrate comprising a
2 recess wherein a work function layer includes a sufficient amount of an
3 impurity comprises providing a substrate comprising a recess wherein a work
4 function layer includes a sufficient amount of an impurity selected from the

5 group consisting of a lanthanide metal, an alkali metal, an alkaline earth
6 metal, scandium, zirconium, hafnium, aluminum, titanium, tantalum, niobium,
7 tungsten, nitrogen, chlorine, oxygen, fluorine, and bromine.

1 27. The method of claim 21 wherein the metal fill layer is selected from
2 the group consisting of copper, titanium, titanium nitride, tungsten and
3 combinations thereof .

1 28. The method of claim 21 wherein removing the work function
2 comprises removing the work function layer by utilizing a slurry comprising
3 periodic acid at a pH from about 4 to about 8 at a molar concentration from
4 about 0.01M to about .06M.

1 29. The method of claim 28 wherein removing the work function layer
2 comprises removing a ruthenium layer at a removal rate of about 900
3 angstroms per minute to about 1500 angstroms per minute.

4 30. The method of claim 28 wherein removing the work function layer
5 comprises removing a titanium nitride, aluminum nitride layer at a removal
6 rate of about 500 angstroms per minute to about 700 angstroms per minute.

1 31. The method of claim 28 wherein removing the work function layer

2 comprises removing a titanium aluminum layer at a removal rate of about
3 150 angstroms per minute to about 350 angstroms per minute.

1 32. A metal gate structure comprising:
2 a dielectric layer;
3 a work function layer, wherein the work function layer includes a
4 sufficient amount of an impurity to shift the workfunction of the work function
5 layer by at least about 0.1 eV; and
6 a metal fill layer comprising copper.

1 33. The structure of claim 32 wherein the work function
2 layer comprises ruthenium, titanium nitride, titanium, aluminum, titanium
3 carbide, aluminum nitride, and combinations thereof.

1 34. The structure of claim 32 wherein the impurity is selected from the
2 group consisting of a lanthanide metal, an alkali metal, an alkaline earth
3 metal, scandium, zirconium, hafnium, aluminum, titanium, tantalum, niobium,
4 tungsten, nitrogen, chlorine, oxygen, fluorine, and bromine.

1 35. The structure of claim 32 wherein the dielectric layer comprises a high
2 k dielectric layer selected from the group consisting of hafnium oxide,
3 hafnium silicon oxide, lanthanum oxide, zirconium oxide, zirconium silicon

4 oxide, titanium oxide, tantalum oxide, barium strontium titanium oxide,
5 barium titanium oxide, strontium titanium oxide, yttrium oxide, aluminum
6 oxide, lead scandium tantalum oxide, and lead zinc niobate.

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